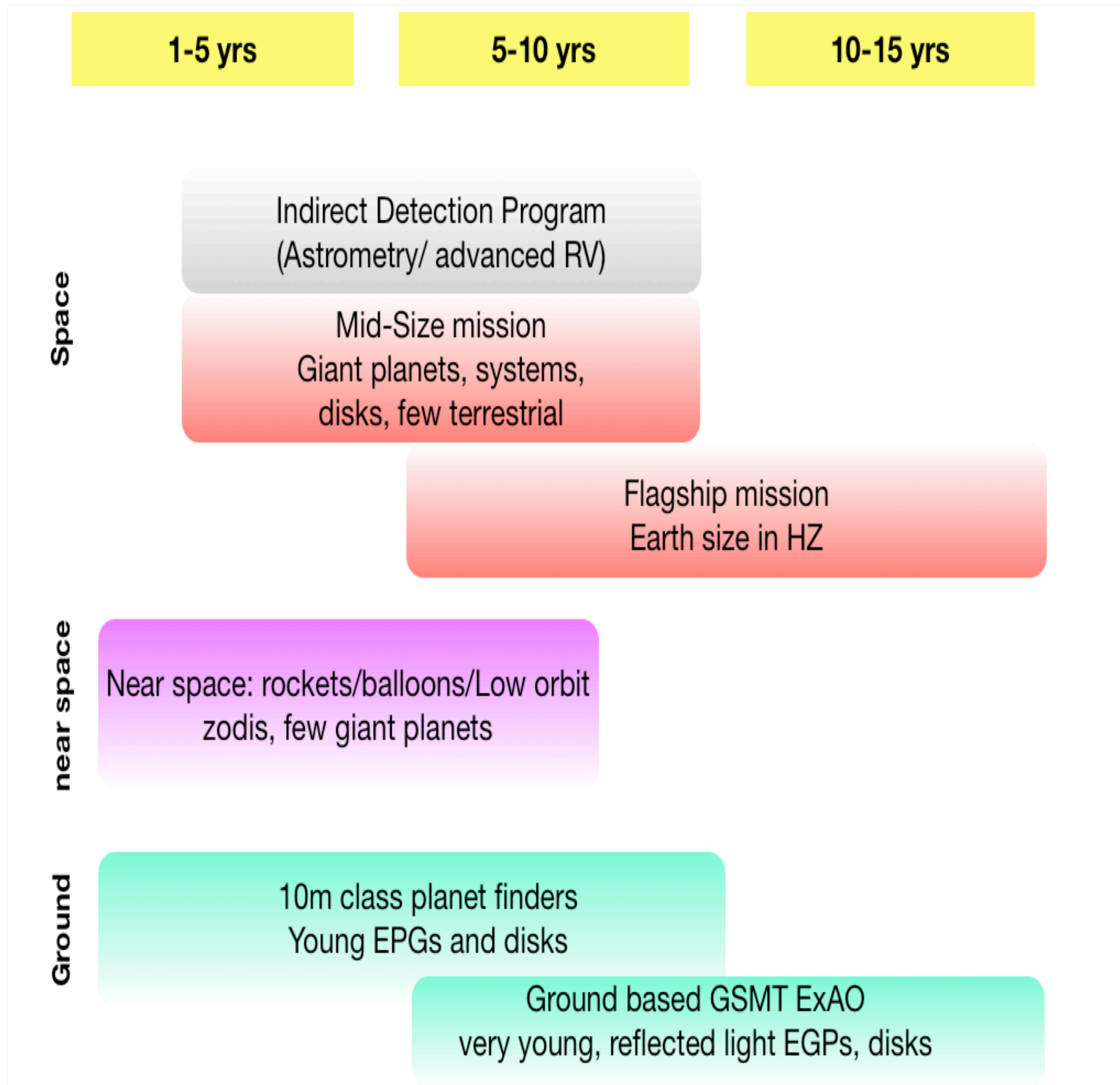
Observatory Architectures

- Connects science to range of observatory scales and costs
- Set’s context and goals for technology development.

Range of Mission Opportunities and Scales for Planet Imaging



Two Basic Architectures for High-Contrast Imaging

- Internal Coronagraphy

  Control stellar halo via diffraction control or interference inside telesocope.

  - Requires active wavefront sensing and control
  - Contrast and iwa scale with telescope diameter
  - Typically narrow band
  - Operations limited by exposure time and iwa

- External Occultation

  Remove starlight via an external starshade and collect planet photons with conventional telescope.

  - Eliminates need for WFSC
  - Contrast and iwa scale with occulter size and distance
  - Challenging engineering and control
  - Operations limited by slew time and revisits

Internal Coronagraph Scales

- Ground Telescopes with ExAO
    - Young giants, debris disks, hot Jupiters
    - Limited by atmosphere and speed of AO
- Suborbital Balloons and Sounding Rockets
    - Bright Jovians, disks, technology development
    - Limited by size and stability
- Small Missions (SMEX/MIDEX)
    - Planet forming regions, debris disks, exozodi
    - Limited by cost (low resolution, reduced contrast)

Internal Coronagraph Scales

- Probe Class (1 - 2 m)
  - Jovian planets, Super-Earths, Exozodi
  - Limited by iwa and integration time
- Flagship Class (4 - 8 m)
  - Terrestrial planets
  - Limited by cost and stability

Mission type/size	Raw Contrast	Augmented contrast	IWA λ/D	Pointing	Mid Spatial WF stability*	Thermal stability	Optics Quality & Fabricatn	Driving science
Internal Coronagraphs								
Ground based 8-m ExAO	1.00E-06	1.00E-07	5	10 mas	5 nm	N/A	x	Young giant planets, debris disks
Ground based 30-m ExAO	1.00E-06	1.00E-08	3	5 mas	5 nm	N/A	x	Formation of planetary systems
Space 0.5-m	1.00E-07	1.00E-07	1	2 mas	1 nm	~ mK	x	debris disks
Space 1.5-m	1.00E-10 @ 10-20% bandwidth	1.00E-10	~2	0.5 mas	30 pm	~ 0.1 mK	x	Super Earth to Jupiters, R = 15
Space 4-m	1.00E-10 @ 10-20% bandwidth	1.00E-11	2-3	0.5 mas	30 pm	~ 0.1 mK	x	Earths to Jupiters, R = 40
Space 8-m	1.00E-10 10-20% bandwidth	1.00E-11	3-4	0.5 mas	30 pm	~ 0.5 mK	x	R=100 Spectroscopy on Earths

External Occulters

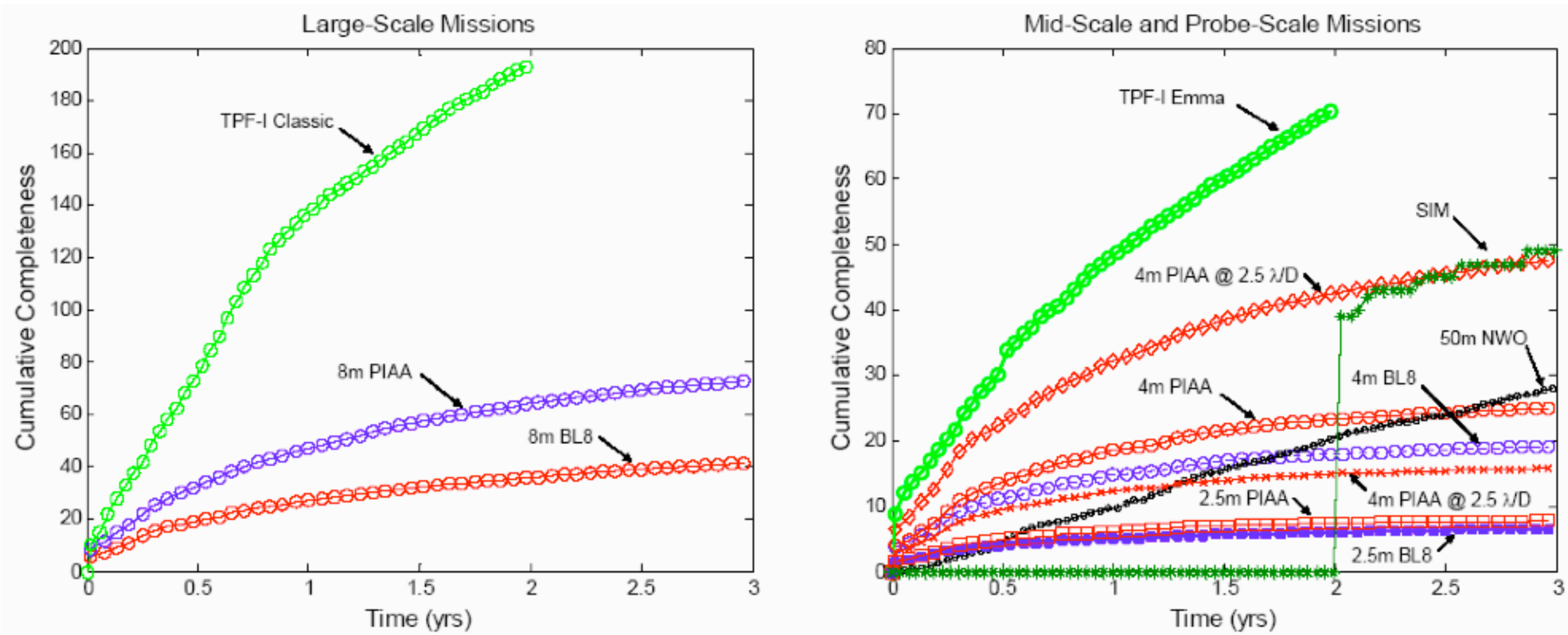
All are flagship scale targeted at terrestrial planets

- •Single External Occulter
    - •Limited by size and distance of occulter
- •Multiple Occulters
    - •Limited by cost and launch vehicles
- •Hybrid Coronagraph/Occulter
    - •Limited by stability and iwa

External Coronagraphs

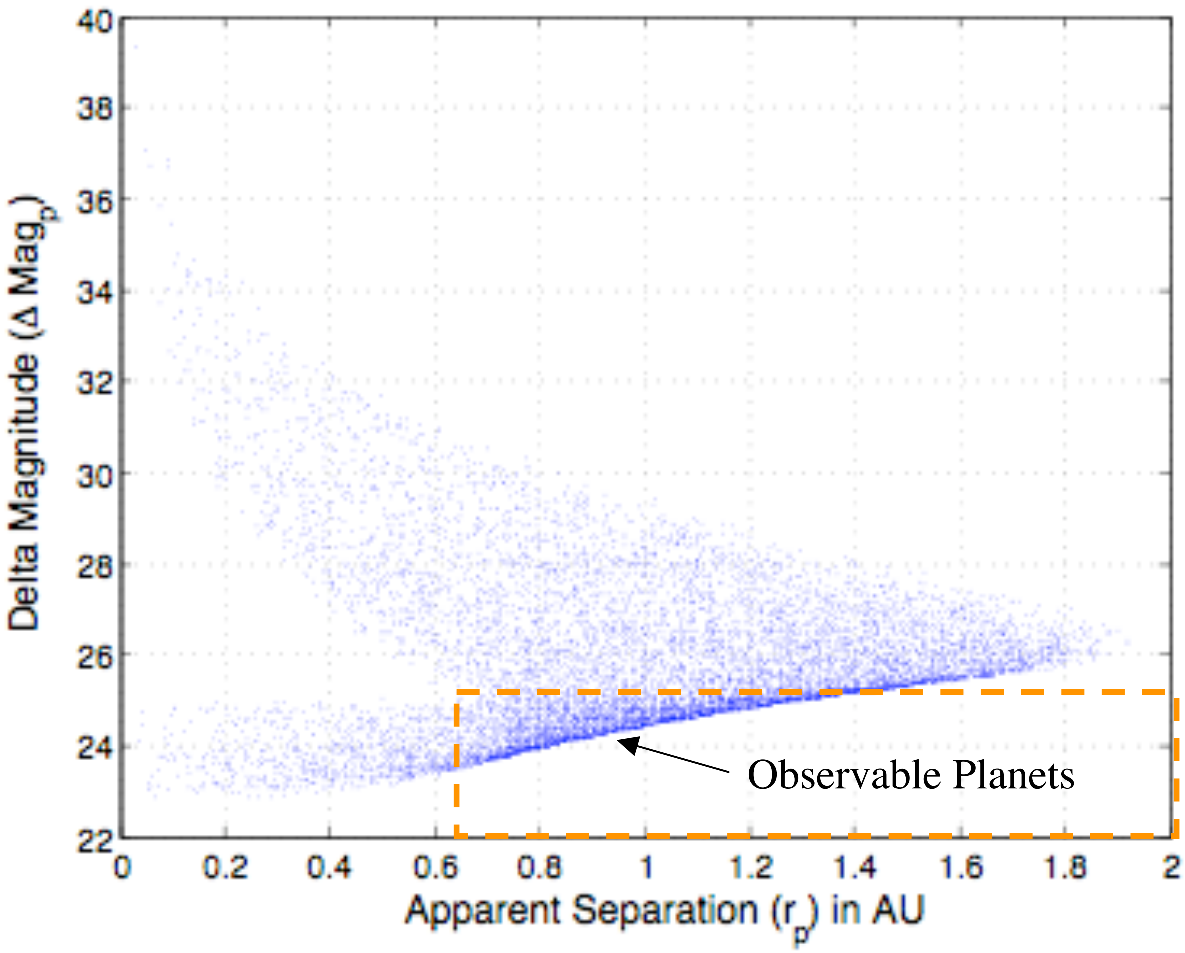
Mission type/size	Raw Contrast	Augmented contrast	IWA (mas)	Telescope Pointing Stability during exposure	Occulter Position to the star	Telescope Thermal stability	Optics Quality & Fabrication	Edge Tolerances	System Integration & Test	Driving science
4-m telescope 50m occulter tip/tip 72000 km separation	1.00E-10 at smallest IWA Full 100% bandwidth 300-1100nm	1.00E-11	60 mas	< 10 mas	0.5 m		On axis, diffraction limited, HST stability	< 1mm	By analysis only	Earths to Jupiters, R = 40
4-m Hybrid 36m occulter tip-tip occulter 50000 km separation	1.00E-10 at smallest IWA Full 100% bandwidth 300-1100nm	1.00E-11	60 mas	< 1 mas	0.5 m		On axis diffraction limited, HST stability	< 1 cm	By analysis only	Earths to Jupiters, R = 40

Mission Completeness Studies



Need to continue refining analysis and create program science estimates for different scales.

Completeness



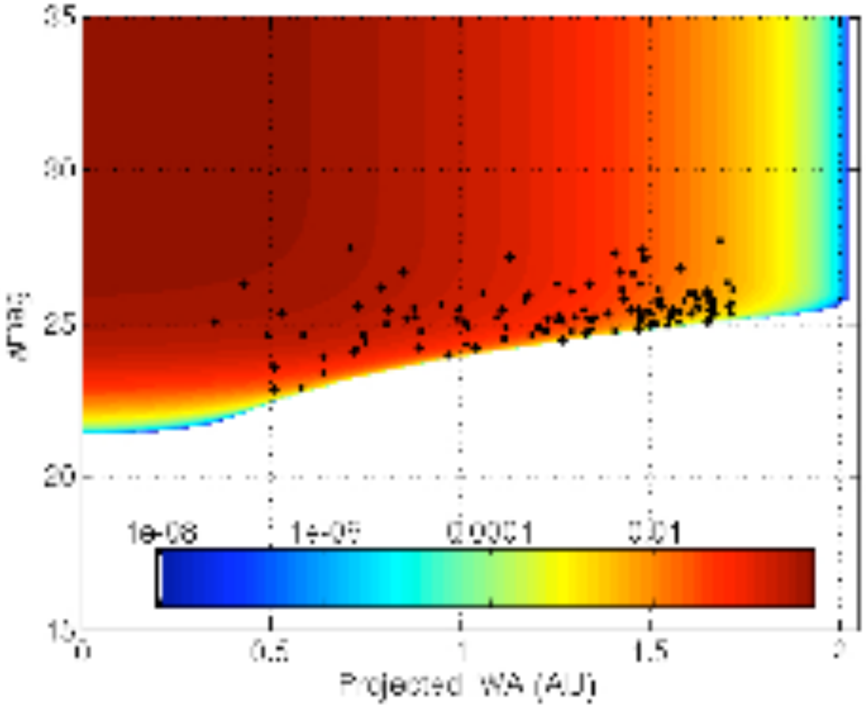
Δmag and separation of 10,000 randomly positioned planets about star with HZ from 0.75 to 1.8 AU and eccentricities up to 0.1

Completeness is the number of planets observed out of a distribution in all possible orbits in the habitable zone of a given target star.

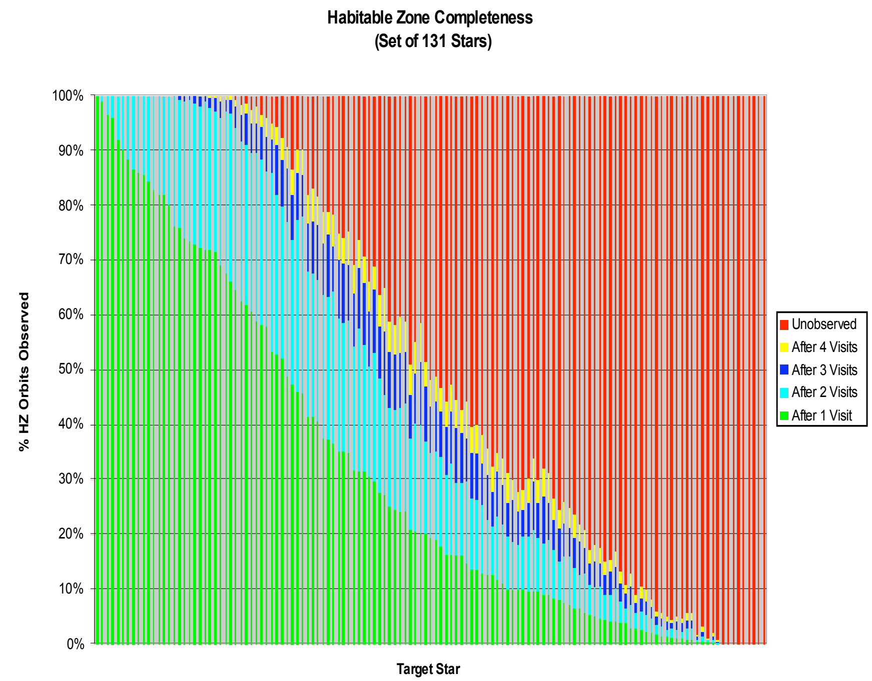
Optimized completeness finds the shortest integration time that still discovers all observable planets for a star of given luminosity.

Total optimized program completeness simultaneously optimizes integration time (min Δmag of planet) and revisits over population of stars to maximize number of planets discovered at fixed probability of missed detection.

Single/Multiple Visit Completeness



iwa = 57 mas



iwa = 60 mas

Optimized Total Program Completeness vs. P_{MD}